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# ON

# THE TORSION OF ARTERIES;

A

CRIPTION OF SOME MODELS, MADE TO ILLUS-
TRATE THE EFFECTS OF TORSION;
WITH REMARKS.

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By THOMAS BRYANT.

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torsion of arteries as a means of arresting hæmorrhage
de such progress in the practice of surgery since it was
duced to our notice by a brief note from Professor Syme
'Lancet' of January 4th, 1868, and at our own hospital
ct with so much support, even to the suppression of
ssure, that it becomes a matter of considerable im-
ce for all surgeons to understand the physiological process
ich the simple twisting of a vessel can prevent the flow
d from its extremity, as well as the means by which the
g of the vessel may be effected in the most certain manner.
s not, however, my intention on the present occasion to
t any length into these questions, for a full detail of the
logical means by which hæmorrhage from a twisted vessel
sted will be found in a paper of mine which was read
the Medical and Chirurgical Society on June 9th, 1868, and
ed in their 'Transactions' of that year. In it the results
ries of experiments on the horse and dog during life, and
ations on the effects of torsion upon arteries of the human
during life and after death, are carefully detailed, the
ments having been commenced on February 4th, 1868,
ntinued for many months.

ilar investigations were subsequently made by Dr.

Humphry, of Cambridge, and brought before the profession in an able paper which was read before the British Medical Association at Oxford in August of the same year, and published in the 'Journal' of the Association on January 2nd, 1869. I had the pleasure of hearing Dr. Humphry's communication, and it was gratifying to find that, upon the whole, his results went to support my own. In a single point of practice we were found to differ, but of that hereafter.

During last winter and summer my own investigations have been continued, and, I may say, they have gone to prove the entire accuracy of the conclusions I had previously arrived at. A suggestion, however, from our well-known modeller, Mr. Towne, led me to inject with wax some vessels of the human subject that had been twisted after death, in order that I might enable him to display in a more permanent and efficient manner than could otherwise be done the varied physiological effects of torsion on the vessels.

For this purpose I removed from a large number of subjects the lower portion of the abdominal aorta with the common, external, and internal, iliac vessels, and having twisted the ends freely, although not off, had them filled with a vermilion-coloured wax injection. These were then dropped into a jar of glycerine and water, and careful sections of the preparations were subsequently made with a sharp scalpel as they were required. From these sections Mr. Towne has made some admirable models, which display in a perfect way most, if not all, of the modes in which hæmorrhage from a twisted vessel is arrested. I purpose in these pages to give a brief description of these models, aided by some drawings which have been made by our artist from them, with remarks upon the subject of torsion.

The models are five in number; they have all been made with wonderful precision from sections of the aorta or common iliac vessels which had been twisted and subsequently injected. Each may, therefore, be regarded as a typical illustration of one of the modes by which hæmorrhage is arrested after torsion. Modifications of these different results, doubtless, are found in practice. I have seen very many; but all may be brought down to one or other of the different types now made permanent by Mr. Towne.

In model No. 1 (Fig. 1), we see the most complete and perfect illustration of the mode by which hæmorrhage is prevented from a vessel that has been subjected to the operation of torsion. At A the external or cellular coat is seen twisted into a knot, through which no injection passed; and at B the inner coat is well displayed fairly divided at the point of torsion of the external coat, and incurved so as to form upon the first rush of blood or injection C a complete valve.

In the model,—where the broad surface of this valve is seen, —the valve is so closed by the force of the injection that no escape took place through it; and it can be well understood how, by the force of the heart's action, the valve thus formed by the incurved inner coat of the vessel would act equally beneficially during life. The greater the force of the blood the more perfect would be the closure of the valve—this valve apparently acting much as the semilunar valves of the heart are known to do.

In model No. 2 (Fig. 2), the valvular incurvation of the divided inner coats (B) and the twisted external coat (A) are well shown, but the valve in this case is not closed, no injection having been employed. It has been introduced here to help to explain Fig. 1, and to render this important physiological process more intelligible.

In model No. 3 (Fig. 3), we see a frequent result of torsion, and a method no less complete than the last by which the flow of blood is arrested in a twisted artery. At A there is the same twisted external coat as we have already seen, and at B the lateral view, if it may be so expressed, of the same divided and incurved middle coat, the valve formed by this middle coat being apparently perfect. But in this case, with the first rush of injection, some small portion passed through the valve before it had completely closed, and at C this portion of injection is seen lying beyond the divided inner tunics of the vessel, and between them and the twisted external coat.

The twisted external coat in this case prevented any escape of blood or injection, supporting most completely the valvular incurvation of the inner tunics.

In model No. 4 (Fig. 4), the same facts are shown as in the last; the broad surface of the valvular incurved inner coat being displayed instead of the lateral or narrow, as in No. 3.

The model represents the same view as No. 1, with the clot of blood or injection which was sent by the first impulse of the injection through the valve before its closure.

Model No. 5 (Fig. 5) was made to illustrate a by no means uncommon effect of torsion upon an artery, which, from a large number of experiments, seems to be the more usual effect of twisting a diseased or atheromatous vessel. The twisted external or cellular coat is shown here as in the other drawings, but the valvular incurvation of the inner coats is not visible, for in this case the inner coats of the vessel seem to have been split up into laminæ, the blood being caught and arrested between the folds of the broken-up and split membrane, hæmorrhage being in this way arrested.

It is to be observed, likewise, that a mass of injection was sent beyond the laminæ of the split inner membrane, and that its escape externally was prevented by the twisted external or cellular coat, as in models Nos. 3 and 4.

With this brief description of the models, as illustrated by the drawings, let us pass on to consider what physiological facts they show, and what conclusions can be drawn from them. The facts seem to be clear and decided.

They show that by the torsion of an artery the inner coats are divided, and in the majority of cases turned inwards, and that in the most perfect examples these incurved coats form complete valves, not unlike the semilunar valves of the heart, on the injection of the vessel, either by the blood of the patient during life, or by artificial injection after death.

They show that in other cases—how many it is difficult to estimate—the valvular incurvation of the divided inner coats is not so perfect as to prevent the passage of a small portion of blood or injection with the first rush of fluid, although it is tolerably clear that the valve is subsequently rapidly closed with any increase or continuance of the injecting force.

They prove, likewise, that in some cases this valvular incurvation of the inner coats is exchanged for a general splitting of the tissues, hæmorrhage being prevented by the clotting of the blood between the irregular laminæ of the divided membrane and the twist of the external cellular coat.

They also prove the great value of the knot formed by the torsion of the external cellular coat; for although in such instances as are shown in figures 1 and 2 the support of such a twist appears to be of secondary importance—the valvular incurvation of the inner coats being apparently sufficient of itself—no one can doubt its value in such cases as figures 3 and 4 are meant to illustrate. And even if, in a large number of such cases, the valve formed by the divided recurved inner coat proves to be perfect after the first rush of the blood current has taken place, the knot formed by the twisted external coat must prove a valuable support, and in doubtful cases, where an imperfect valve exists, it must be of still greater importance. In figure 5 the presence of the twisted external coat is surely of value, not only by forming an obstacle to the immediate escape of blood through the broken-up inner membrane, but by giving time to allow of complete coagulation of the blood which has been caught between the laminæ of the inner coats.

We come, therefore to this conclusion—that although there is no physiological necessity, in the most complete examples of torsion of an artery, for the preservation of the knot formed by the twisted external coat, there is in the imperfect examples; and as it is impossible for the surgeon to know during life, in any given case, whether the valvular incurvation of the inner coat has taken place in the most complete way or not, and as it is at least probable that an imperfect incurvation of the inner coat exists, it seems to be more prudent for the surgeon to act on the side of caution, and to preserve this twisted external coat in its integrity in all cases.

I look upon the valvular incurvation of the inner coat as the chief means adopted by nature for the arrest of hæmorrhage, and the twist in the external coat as an all-important additional security; the elastic and yet brittle inner tunic, with its tendency to adhesive inflammation, requiring, in all but the most perfect examples, during the first few hours after torsion, the support of the tougher external one.

The more the inner coat is broken up by the twisting of the vessel, the greater is the need of the external coat to give it support.

The more the end of a large artery is twisted, the more is the inner coat broken up and the greater is the danger of disturbing its valvular incurvation.

When the end of a healthy vessel is twisted off, the inner coat is, as a rule, greatly broken; when the end of a diseased vessel is so treated, it is split into fragments.

When a limited number of rotations of the forceps—two, three, or four—are applied to a healthy vessel, the valvular incurvation of the inner tunic is, as a rule, complete; and the more diseased the artery, the fewer are the rotations required.

The propriety of twisting off the end of an artery or leaving it on becomes, therefore, a matter of great importance, and a great practical question which has yet to be decided.

From the remarks I have already made it will be evident that my own opinions tend to support the practice of leaving the twisted extremity of the vessel *in sitû*. Dr. Humphry has, however, come to the opposite conclusion. How it is, therefore, that we differ upon this point may claim some brief notice, for his authority is so high that his opinions are readily accepted and his practice followed.

First of all, Dr. Humphry clearly shows in his paper that he does not attach so much importance to the reflection of the inner coat, as a barrier to the flow of blood, as he does to the twisting of the outer coat, forasmuch as by this, he states, "the inner coat is not only forced into, but is held in, its new position; accordingly, if a syringe be attached to an artery thus twisted, and water be injected, considerable resistance to the escape of the water is presented; but if the twisted portion of the outer coat be cut through, or dissected off, the water very soon escapes. It has little difficulty in finding its way through the inner coat, or of separating the surfaces, when the support afforded by the outer coat is withdrawn."

These facts are undoubtedly correct, my own experiments have confirmed them; but the test applied to the inner coat by dissecting off the outer is a very severe one, to say the least of it, and applies to conditions that do not naturally exist. The facts tend, moreover, to prove the value of the twisted external coat rather than the weakness of the inner tunic, and suggest to the surgeon the wisdom of doing nothing to weaken the strength of the twisted external coat. Yet it is to be remarked that Dr. Humphry in most of his experiments twisted off the ends of the vessels, and in doing this, I have little doubt, in a large number of cases he not only destroyed the valvular incurvation of the inner coat, and so broke up the tissues as to render the support afforded by the external coat an absolute necessity, but by the same act of twisting off he likewise weakened the external coat upon which safety under such circumstances absolutely depended; for repeated experiments have proved to me that when a mixture of glycerine and water of the sp. gr. of blood is thrown into a large artery, the end of which has been twisted off, it is far more frequent to find some leaking of the vessel through the divided extremity than when the end of the vessel has been only twisted three, four, or five revolutions.

When the arteries are diseased this fact comes out still more clearly, for in a diseased artery the inner coat is so brittle as to break and incurve on one or two rotations of the forceps. One or two more rotations break up the inner membrane into pieces very like those seen in Fig. 5, and by twisting the end off the artery it is very apt to be destroyed.

The twisting off of the end of a large artery crushes up the inner membrane, and too often lacerates the external, destroying by one act the valvular incurvation of the inner tunic, upon which the arrest of hæmorrhage so much depends, and weakening the support which the external coat would otherwise give, and which under such circumstances is so much required.

In a recent amputation of the thigh, where the vessels were much diseased, the truth of these remarks was well illustrated, for when I twisted the femoral artery three complete revolutions the end become so loose that I thought it was off, and leakage followed, but when I took the vessel up again, having cut off the lacerated extremity and twisted its end two rotations, good success ensued. This case illustrates the practical truth that in applying torsion to a diseased vessel a more limited number of rotations of the forceps should be made than to a sound artery.

What we want to effect by the torsion of an artery is a laceration and incurvation of the inner tunic, and to support this incurved membrane by the twist of the external coat. We do not want to crush up the inner tunic too much, or to weaken in any way or to lacerate the external. By twisting off the end of the vessel I have abundant evidence that we incur a greater risk of falling into both of these errors than by making a limited number of rotations of the forceps and leaving the end of the vessel on. All my experiments and observations tend to prove this in a direct way, and the facts that Dr. Humphry has supplied by his experiments go to support the same views.

If it be generally true, therefore, as a modern writer in the last edition of 'Holmes's Surgery' has so dogmatically asserted, "that torsion is unsuitable for diseased arteries, and large vessels, even though healthy, cannot be invariably secured by it, Professor Humphry having found in his experiments on animals that the outer coat is sometimes too much weakened by the rotation," he should have added *when rotated off,* for it was made true only from the fact that torsion was carried to too great an extent. For all my experiments and nearly two years' experience have convinced me of the following conclusions:

That torsion may be safely applied to all arteries of the extremities and to all those of the trunk which are in size less than or equal to the femoral. To the carotid and iliac vessels it has yet to be applied.

That it is almost as applicable to diseased as to healthy vessels, the former requiring fewer rotations of the forceps than the latter.

That in large healthy vessels, such as the femoral, the extremity should be twisted till resistance has been overcome, but no further—three, four, or five rotations of the forceps being, as a rule, all that is needed. These rotations should be made sharply.

That in large atheromatous vessels the same rule should be applied, two or three rotations of the forceps generally sufficing.

That in all small vessels torsion may be applied very freely, even to the separation of the end, although when evidence of disease exists it is better to proceed with more caution and not to twist off.

That in every case where a large artery is twisted it is advisable to allow a current of blood to flow into the vessel before the forceps are removed from its end. This caution not only tests the completeness of the act in all cases, but in doubtful ones facilitates the coagulation of the blood in the meshes of the broken-up inner membrane.

For nearly two years I have practised torsion upon arteries and veins of all sizes up to the femoral, and I have seen it practised likewise in all ways. During that period I have never, with one or two exceptions, applied a ligature to a divided artery in an uncomplicated case. No instance of secondary hæmorrhage from a large or small vessel has yet been recorded after its use. I have certainly had more cases of primary union of wounds during this period. Stumps have healed more kindly and wounds have closed more rapidly. I have not seen anything to make me hesitate about the value of the practice, but I have seen much to encourage me in its adoption.

It may require some care in its application, but not more than the taking up of a large vessel, and the application of a ligature to its end with neatness. Any surgeon or dresser who can do the one can do the other, and I am not sure that to the inexpert one mode of arresting hæmorrhage is more difficult than another. In the practice of torsion to such a large artery as the femoral even rough handling has proved successful (as it has before in the application of a ligature); and when torsion succeeds at the time, every hour that passes strengthens the probabilities of success, whereas, in the case of the ligature, such cannot be said to be invariably the fact.

Torsion may, in exceptional cases, be troublesome to perform; in others it may prolong an operation; and in some cases it may even fail to arrest hæmorrhage. But, upon the whole, the adoption of torsion must be looked upon with favour, for it certainly is applicable in the majority of cases, it tends to simplify surgery, to hasten the repair of wounds, to discourage suppuration, and to add to the general safety of our patients. To apply torsion it is only necessary to seize the artery firmly, and to twist it sharply till resistance ceases. Any forceps that hold firmly and do not tear will do; although for large vessels a broad end is required.

At Guy's Hospital, up to the present time, the femoral artery has been twisted at least twenty-two times, the tibial seven, and the brachial three. I have applied torsion in upwards of a hundred cases altogether; no difficulty of any importance has been experienced in any case, and nothing but a good result has yet been recorded. I may add, likewise, that amongst our house-surgeons it is proverbial that since torsion has been employed secondary hæmorrhage after operations has been comparatively of rare occurrence.

## DESCRIPTION OF PLATE.

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### Fig. 1.

A. Twisted external cellular coat.
B. Incurved inner coat, showing broad surface of the valve.
C. Injection representing blood, none of which passed through the valve.

### Fig. 2.

A. Twisted external cellular coat.
B. Incurved inner coat projecting into the vessel, but not closed by the force of the injection.

### Fig. 3.

A. Twisted external cellular coat.
B. Incurved inner coat, showing the lateral surface of the valve completely closed.
C. Injection, some of which passed through the valve.
D. Injection which passed the valve before it was closed, but was retained by the twist in the external coat.

### Fig. 4.

Represents the same as Fig. 3, with the broad surface of the valve.

### Fig. 5.

A. Twisted external cellular coat.
B. Inner coats split into laminæ.
C. Injection representing blood caught between the laminæ.
D. Injection or clot retained by twist in the cellular coat.

E. In each figure represents the different varieties of ends of a twisted artery.

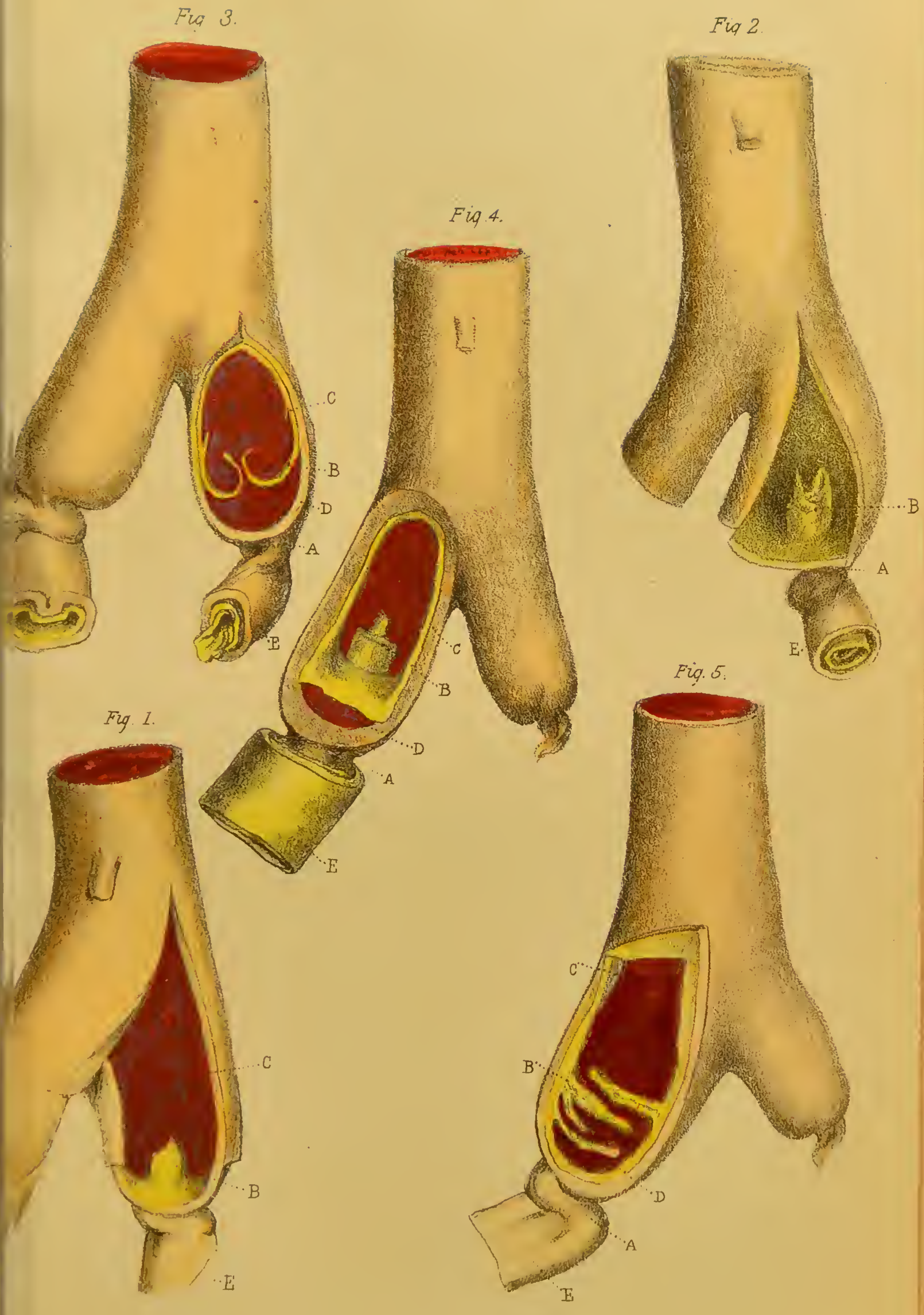

Fig 3.

Fig 2.

Fig 4.

Fig. 1.

Fig. 5.

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